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Length-weight relationship and condition factor of an indigenous fish, *Triplophysa marmorata* (Heckel, 1838), from Kashmir Valley

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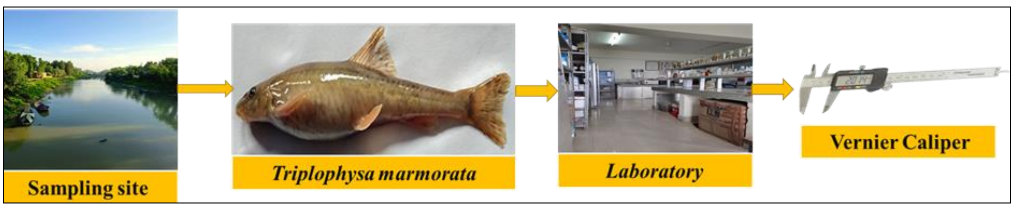
Abstract
This study was undertaken to understand the length-weight relationship (LWR) and condition factor of freshwater fish species from of Kashmir valley. A total of 150 *Triplophysa marmorata* specimens from the Nemacheilidae family were collected in the Kashmir valley with the assistance of local skilled fishermen. The length-weight relationship yielded a b-value of 3.42 and a condition factor of 0.80. Additionally, the descriptive analysis of LWRs in this study revealed an 'r^2' of 0.91, although the intercept 'a' was 0.00000115. Comprehending the LWR is essential for fisheries science and management, shedding light on fish population dynamics and health. The length-weight relationship is a vital foundation for studying fish growth patterns in the Kashmir valley, supporting the conservation of endemic species. This study enhances our knowledge of length-weight relationships and condition factors, specifically focusing on *Triplophysa marmorata* in the Kashmir valley.

Keywords: Length-weight relationship, Kashmir valley, *Triplophysa marmorata*, condition factor

Introduction
Understanding the Length-Weight Relationship (LWR) in fish is essential for assessing fish population health and condition (Bolger & Connoly, 1989) [4]. This method plays a crucial role in fisheries and fish biology by establishing a mathematical connection between a fish's length and its average body weight within a specific length range. It aids in assessing fish weight (Beyer, 1987) [2] and is indispensable for analyzing biological and fisheries data, providing insights into historical events related to specific species and population characteristics, as well as revealing changes in growth and weight (Moutopoulos & Stergiou, 2002; Nile *et al*., 2013) [16, 18]. Estimating biomass often relies on length-weight regressions due to the time-consuming nature of obtaining direct weight measurements. Length-weight relationships (LWRs), growth, condition factors (K), recruitment, and fish mortality are essential tools in fishery biology, especially when studying species at the foundational level of the food web. The establishment of a relationship between weight and length is vital for calculating fish population production and biomass. Comprehending LWR holds significant importance, serving multiple critical purposes. It enables the quantification of fish condition, facilitates cross-regional comparisons of living conditions within the same species, assists in calculating biomass from length data, and transforms length growth equations into weight growth equations.



Each of these applications serves a unique purpose in fish stock assessment and management models (Coello *et al*., 2021; Soykan and Kinacigil, 2021) [6, 23]. Additionally, LWR, through its size distribution, can be a valuable tool for estimating the quantity of discards for a particular species (Lamprakis *et al*., 2003; Torres *et al*., 2012) [13, 26]. This relationship offers insights into an individual's overall well-being, variations between sexes, growth patterns, first-season maturity, breeding, and gonadal production (Wanjari *et al*., 2019, 2021; El-Aiatt, 2021) [28, 29, 8]. In fisheries management and research, biometric relationships are essential for converting field-collected data into appropriate indexes (Ecoutin and Albaret, 2003) [7]. Biomass, often estimated indirectly through length-weight regressions due to the time constraints of direct weight measurements in the field, is a crucial factor for calculating production, using methods such as the Ricker algebraic approach (Watson and Balon, 1984) [30]. Length-weight relationships, condition factors (K), and recruitment, data on growth, and fish mortality are critical tools in fishery biology, particularly when dealing with species at the base of the food chain. These relationships are essential for determining the production and biomass of fish populations, enabling morphological comparisons among species and populations in different habitats or regions. Furthermore, L-W relationships are commonly employed to monitor seasonal variations in fish growth and compute condition indexes (Safran, 1992; Richter *et al*., 2000) [20, 19]. Length-weight relationships are extensively utilized to convert growth-in-length equations into growth-in-weight, especially in stock assessment models. This enables the estimation of stock assessment biomass from a limited sample size and serves as an indicator of well-being of fish condition. Furthermore, these relationships prove invaluable in comparing the life histories of specific species across diverse regions and delving into various aspects of fish stock population dynamics (Binohlan and Pauly, 1998; Moutopoulos and Stergiou, 2002) [3, 16]. Moreover, data pertaining to both length and weight offer essential insights into climate and environmental shifts, as well as alterations in fishery practices. Therefore, changes in size over a definite period can reflect shifts in average age due to these factors (Samat *et al*., 2008) [21]. The quantitative characterization of the relationship between length and weight within a fish population is an essential tool in fisheries science and management, enabling the assessment of natural fish populations (Tsoumani *et al*., 2006; Britton and Davies, 2007) [27, 5]. This relationship, expressed as $W = aL^b$ in the length-weight (L/W) equation, allows for the characterization of a specific population, disregarding individual variations, and provides insights into the population's condition and fitness (Le Cren, 1951) [14]. Moreover, it enables comparisons between populations of the same species across different times or regions. The availability of these parameters for a specific population empowers fisheries managers and scientists to estimate weight data based solely on length distribution data, as demonstrated by Froese (2006) [9]. Condition-oriented indices, such as Fulton's condition factor and Le Cren's relative condition factor, derived from the length-weight relationship, have proven to be valuable tools in fisheries science (Froese, 2006) [9]. Therefore, the objective of this paper is to present the length-weight relationship (LWR) and condition factor values of the freshwater fish Triplophysa marmorata from the Kashmir valley.

Materials and Methods

During the period spanning August 2018 to January 2019, a total of 150 samples of *Triplophysa marmorata* were collected. Freshly caught fish specimens were preserved in ice and delivered to the laboratory of Fisheries Resource Management (FRM), Faculty of Fisheries, SKUAST-Kashmir. Species were identified using standard literature references from Talwar and Jhingran (1991) [24] and Jayaram (1999) [12]. Total length (TL) and body weight (W) were estimated with a precision of 0.1 cm and 0.01 g, respectively, using a digital caliper and electronic weighing balance.

For length-weight relationships (LWRs)

In the course of the study, each fish specimen's weight was meticulously recorded with an accuracy of one gram. The Length-Weight Relationships for each species were individually established using the equation proposed by Le Cren (1951) [14]. In this equation, the body weight of the fish specimens (W) was measured in grams, the total length (L) was measured in millimeters, 'a' represented the intercept, and 'b' denoted the slope of the regression line. The relationship between length and weight was expressed in logarithmic form. When interpreting the results, the estimated regression coefficient value was analyzed. A coefficient value nearing 3 indicated isometric growth in the fish species, signifying that weight increased proportionally with length. Conversely, if the coefficient deviated from 3, it indicated either negative allometric growth ($b < 3$), where weight increased at a slower rate compared to length, or positive isometric growth ($b > 3$), where weight increased at a faster rate compared to length.

Condition factor

The condition factor (K) of the studied fish species was computed using Fulton's index (Fulton, 1904). The formula for Fulton's index is as follows.

K = (W / L3) * 100

Here, "K" represents the condition factor, "W" represents the total body weight (in grams) of the fish specimens, and "L" represents the total length of the specimens (in millimeters). The condition factor offers insight into the overall well-being and health of the fish species, with higher values typically indicating better condition and growth. Data analysis was conducted using statistical methods, utilizing both basic Excel and SPSS version 25.

Results and Discussion

In this study, we conducted a descriptive analysis of length-weight relationships (LWRs) and estimated key parameters (Table 1). The results showed that the intercept 'a' was 0.00000115 while the slope 'b' was estimated at 3.42, with a coefficient of determination 'r^2' calculated as 0.91. A visual representation of the length-weight relationship is presented in Figure 1. The Length-Weight Relationship (LWR) is a vital parameter for understanding fish growth patterns. Typically, "b" values in this relationship fall within the range of 2.5 to 3.5 (Froese, 2006) [9] or 2 to 4 (Tesch, 1971) [25]. The species examined in our study displayed a "b" value of 3.42, which falls within the expected ranges. This finding is consistent with the results reported by Sheikh and Ahmed (2019) [22] and Mushtaq *et al*. (2023) [17].

It's essential to note that variations in "b" values can be attributed to various factors, such as sample size, seasonal variations, habitat characteristics, gonadal maturity, gender, stomach fullness, health status, and fish condition, as well as preservation methods, and variations in the apparent length ranges of collected samples. These factors were not explicitly considered in our study. Moreover, growth patterns in fish species can vary not only among different populations of the same species but also within the same population across different years. These variations can be influenced by factors like food availability, water quality, and various biological, temporal, and sampling considerations. In our study, the condition factor was determined to be 0.8, indicating the well-being of the fish within the delicate ecosystem of the Kashmir valley, falling within the optimal range. It's important to recognize that a fish's condition factor is influenced by a range of internal and external factors, as highlighted by several researchers. Studies conducted by Hasim *et al*. (2021) [11], Mobley *et al*. (2021) [15], and Yulianto *et al*. (2020) [31] have emphasized that fish condition factors can be influenced by factors like gender, gonad maturity, climate, and food availability. These findings suggest that a fish's condition factor is not solely dependent on its size or weight but is also impacted by physiological and environmental factors that affect its overall health and well-being, including reproductive status, environmental conditions such as temperature and water quality, and the availability and quality of food resources.

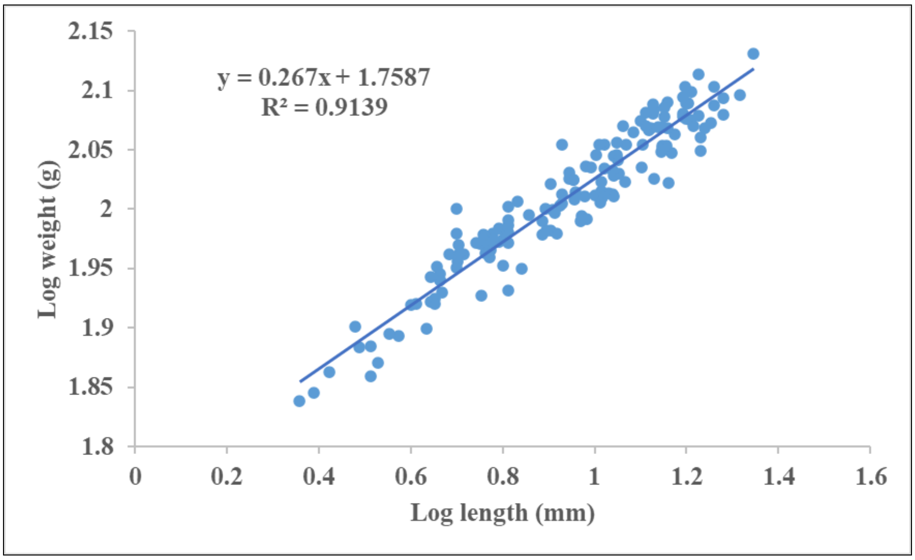


Fig 1: Length-weight relationship of *Triplophysa marmorata* collected from Kashmir valley

Table 1: Estimated parameters from length–weight relationship of *Triplophysa marmorata* collected from Kashmir valley

n	TL range (mm)	Weight range (g)	Regression parameters				
	Min-max	Min-max	a	b	95% CL of a	95% CL of b	r^2
150	54.85-135.22	2.28-22.19	0.00000115	3.42	0.000000517-0.000002550	3.250922892-3.595677	0.91

Note: n (sample size), TL (total length), W (body weight), a (intercept), b (slope of the linear regression), CL (confidence limits), and r^2 (coefficient of determination)

Conclusion

This study aimed to understand the Length-Weight Relationship (LWR) in fish, which is crucial for assessing fish population health. The study found a 'b' value of 3.42, falling within the typical range of 2.5 to 3.5, and a coefficient of determination 'r^2' of 0.91. While variations in 'b' values can be influenced by factors not considered in this study, it's important to note that fish growth patterns can vary due to factors like food availability and water quality. The condition factor, determined to be 0.80, indicates the well-being of the fish in the Kashmir valley's ecosystem. However, it's important to recognize that a fish's condition factor is influenced by various factors, including gender, gonad maturity, climate, and food availability, which were not explicitly considered. Understanding the LWR is fundamental for fisheries science and management, providing insights into fish population dynamics and health. This study contributes to our knowledge of the length-weight relationships and condition factors of freshwater fish, particularly *Triplophysa marmorata* in the Kashmir valley.

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Authors' contribution

Aadil Hussain Magloo: Involved with the idea of research, sampling, and paper writing.

Farooz Ahmad Bhat: Major Advisor of first author and guiding for site selection and overall study.

Tasaduq Hussain Shah: Guidance of research work.

Rinkesh Nemichand Wanjari: Graphical abstract.

Asim Iqbal Bazaz: Helped with sampling, laboratory analysis.

Shakir Ahmad Mir: Helped paper writing.

Shahid Gul: Helped paper writing.

Junaid Sidiq: Helped with sampling and laboratory analysis.

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